UNITED STATES PATENT APPLICATION

FOR

**SYSTEM AND METHOD FOR DYNAMIC CONTROL OF DATA PACKET
FRAGMENTATION THRESHOLD IN A WIRELESS NETWORK**

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SYSTEM AND METHOD FOR DYNAMIC CONTROL OF DATA PACKET
FRAGMENTATION THRESHOLD IN A WIRELESS NETWORK

This application claims benefit of U.S. Provisional
5   Application No. 60/226,494 filed August 18, 2000.

FIELD OF THE INVENTION

The present invention relates to the field of
10 networking.   In particular, the invention relates to a
system and method in a wireless network system for
dynamically controlling a data packet fragmentation
threshold in response to changes in network environment
conditions, including radio frequency (RF) interference
15 and/or data rate changes.   In addition, the invention
relates to a system and method for sending a control
signal to wireless units to enable request to send
(RTS)/clear to send (CTS) and/or fragmentation modes of
operations.
20

BACKGROUND OF THE INVENTION

The ability of users to access programs and share
data over local area networks (referred to as "LANs") has
25 become a necessity for most working environments.   To
improve efficiency and ease of use, certain enhancements
may be added to a LAN such as remote wireless access.   By
providing remote wireless access, a wireless LAN (WLAN) is
formed.
30   As described in U.S. Patent No. 5,987,062 issued to
Netwave Technologies, Inc., now owned by Nortel Networks
Limited of Ontario, Canada, one type of WLAN employs
dedicated stations, which are referred to as access points
(APs).   Therein, each AP is a relay station that includes
35 a radio frequency (RF) transceiver that receives radio

data packets from a mobile unit (MU) such as a notebook-
type computer with a suitable adapter card as described in
U.S. Patent No. 5,987,062.   Thereafter, the AP transmits
the data packets to the fixed backbone network.   Of
5   course, the AP may receive data from the fixed backbone
network and transmit it to one or more mobile units.

Before data transmission can occur between the fixed
backbone network and an MU by way of an AP, the AP must
first authenticate MU.   The authentication is accomplished
10 by the MU transmitting a request for authentication
message to the AP, and the AP sending back a successful
authentication message back to the MU.   Once the MU has
been authenticated, the MU has to associate itself with
the AP.   The association is accomplished by the MU
15 transmitting a request for association message to the AP,
and the AP sending back in a successful association
message. The authentication and association transmission
are specified in the Institute of Electrical and
Electronics Engineers (IEEE) 802.11 standard.   Once the MU
20 has been properly authenticated and associated with the
AP, then data transmission between the MU and the fixed
backbone network can occur.

A problem with current wireless networks deals with
the situation where there is significant RF interference
25 in the wireless communications link coupling an AP with
the associated MU(s). Typical sources of significant RF
interference for wireless network systems include Blue
Tooth devices, cellular telephones, microwave ovens, and
other devices that transmit RF signals.   When significant
30 RF interference is present in the wireless medium of a
wireless network system, generally more errors occur in
the transmission of data between an AP and the associated
MU(s).

The data error of the transmission is not only a function of the RF interference present in the wireless medium, but also of the size of the data packets. In an RF interference free environment, the wireless medium can
5   support the transmission of data packets having relatively long data length without substantial transmission errors occurring. Thus, in an RF interference free environment, the optimal data throughput for the wireless medium occurs when the data packets are at maximum data size, which in a
10   802.11 compliant wireless network system is 2304 bytes. When RF interference increases in the wireless medium, more transmission data errors occur for the same data packet size. However, if the data packet size is reduced, the transmission data errors can be substantially reduced.
15   Thus, in an RF interference environment, generally there is an optimal data packet size (less than the maximum data packet size) where the data throughput is maximum.

In prior art wireless network systems, a network system administrator occasionally gauges the RF
20   interference present in a wireless network system in order to manually determine the optimal data packet size. This is accomplished by the system administrator causing an AP to send many test patterns to a designated MU with varying data packet sizes, and then measuring the data throughput
25   for each of the data packet sizes. Using this technique, the system administrator can determine the optimal data packet size.

Then, the system administrator manually sets the fragmentation threshold for each AP and MU of the wireless
30   network system above the optimal data packet size. The fragmentation threshold sets the upper limit of the data portion of a packet. That is, if the payload size of a packet is greater than the fragmentation threshold, the data packet is fragmented so that each fragment

transmitted has a payload that is less than the threshold.
If the payload size of the packet is less than the
fragmentation threshold, the packet is not fragmented, and
simply transmitted.

5   The problem with this technique is that RF
interference in a wireless environment is typically very
dynamic, and therefore, a system administrator cannot
practically determine and adjust for the optimal
fragmentation threshold for every change in the wireless
10   environment. For example, a person in a business office
or a home can turn on the microwave oven for 30 seconds.
During that 30-second period, the RF interference in the
wireless medium increases. However, it would be
impractical or even impossible for a system administrator
15   to gauge the wireless environment for the purposes of
determining the optimal fragmentation threshold each time
a person turns on a microwave oven or some other RF
interference source.

      Another problem with current wireless network systems
20   deals with fragmentation threshold as described above, and
data transmission using request to send (RTS)/clear to
send (CTS). In a 802.11 compliant wireless network
system, the AP and the associated MUs are all able to use
the wireless medium using carrier sense multiple access
25   with collision avoidance, referred to as CSMA/CA. Using
CSMA/CA, an MU first determines if the wireless medium is
either idle or busy. If it is idle (i.e. the medium is
available for transmission), the MU simply transmits the
data packet to the AP, and the AP responds by sending an
30   acknowledgement packet back to the AP if the data packet
was successfully received. If the wireless medium is
busy, the MU will backoff from sending the data packet for
a random time period. After this period, the MU checks

the wireless medium again to determine if it is idle or busy.

A problem with CSMA/CA may occur when MUs are within the range of an associated AP, but are outside of each

5   others' ranges.   In this case, when the first MU transmits a data packet to the associated AP, the second MU fails to hear that transmission.   As a consequences, the second MU may falsely detect that the wireless medium is idle, and transmit its data to the AP, resulting in a collision of

10   the data.   The likelihood of this occurring increases when there is a relatively high count of MUs associated with an AP.   A system administrator can correct or ameliorate this problem by employing request to send (RTS)/clear to send (CTS) transmissions throughout the wireless network system

15   or at least throughout the sub-system comprising the AP and its associated MUs.

Using request to send (RTS)/clear to send (CTS) transmissions, an MU first sends a request to send (RTS) packet to the associated AP.   If the following time slot

20   is already reserved by another MU for transmission of a data packet, the AP simply does not send back a CTS packet.   However, if the following time slot has not been reserved for transmission, the AP sends a clear to send (CTS) packet to the transmitting MU indicating that a

25   following time slot is reserved for transmission by the transmitting MU.   All other associated MU(s) detecting the CTS packet know that the following time slot is already reserved for transmission by the transmitting MU.   Thus, this avoids the problem of MUs being outside the range of

30   each other since the associated MUs will detect the CTS packet sent by the AP.

Typically, request to send (RTS)/clear to send (CTS) transmission are used when there is a relatively high number of MUs associated with an AP.   So that request to

send (RTS)/clear to send (CTS) transmissions is effective
to avoid collisions, it should be enabled for all MUs and
associated AP of an AP/MU cluster. However, as alluded to
above, a problem with current wireless network systems is

5   that the system administrator has to manually enable each
AP and MU when RTS/CTS transmission is desired. Likewise,
a system administrator has to enable each AP and MU when
fragmentation is desired. Since there can be many APs and
MUs in a wireless network system, having a system

10   administrator go around to all of these units to enable
RTS/CTS transmissions and/or fragmentation is cumbersome,
costly and time-consuming.

        Thus, there is a need for a system and method for
dynamically controlling a data packet fragmentation

15   threshold in response to changes in network environment
conditions, including radio frequency (RF) interference
and/or other parameters in a wireless network system.
There is also a need for a system and method of globally
controlling all MUs (referred to in this application as

20   wireless units (WUs) since they need not be mobile)
associated with an AP to enable RTS/CTS transmissions
and/or data packet fragmentation. Such systems and
methods are provided herein in accordance with the
invention.

25

SUMMARY OF THE INVENTION

        An aspect of the invention relates to a method of
automatically adjusting a fragmentation threshold for data

30   transmissions between an access point and one or more
associated wireless units via a wireless medium associated
with a wireless network system. The method comprises
determining a transmission error factor indicative of
errors occurring in the transmission of one or more data

packets between the access point and the one or more
associated wireless units, and automatically adjusting the
fragmentation threshold based on the transmission error
factor.

5   The transmission error factor can be determined by
transmitting one or more data packets, and determining the
transmission error factor based on the number of
acknowledgement packets received in response to the
transmitted one or more data packets.   The transmission
10 error factor can depend on the number of errors occurring
in the transmission of the one or more data packets for a
given time period.   Also, the transmission data error can
depend greater on transmission errors occurring
successively (i.e. clusters of transmission errors) than
15 on errors occurring sporadically.

        The automatic adjusting of the fragmentation
threshold can be accomplished by comparing the
transmission error factor to an upper threshold and
decreasing the fragmentation threshold if the transmission
20 error factor is above the upper threshold.   In the other
direction, the fragmentation threshold is adjusted by
comparing the transmission error factor to a lower
threshold, and increasing the fragmentation threshold if
the transmission error factor is below the lower
25 threshold.   The changes in the fragmentation threshold can
be by a fixed quantity each time the fragmentation
threshold is adjusted, or by a divisional factor, wherein
the fragmentation threshold is equal to a pre-determined
fragmentation threshold divided by the divisional factor.
30 This pre-determined fragmentation threshold can be the
maximum data packet size for transmission over the wired
backbone network, or the maximum data packet size for
transmission over the wireless medium.

The above method can be performed by an access point, a wireless unit, or other device in a wireless network system.   The above method can also be embodied in a software routine stored on a machine readable medium.

5   Another aspect of the invention relates to a method of automatically adjusting a fragmentation threshold for data transmissions between an access point and one or more associated wireless units via a wireless medium associated with a wireless network system.   The method comprises determining a transmission error factor indicative of errors occurring in the transmission of one or more data packets between the access point and the one or more associated wireless units;   automatically adjusting the fragmentation threshold based on the transmission error factor, wherein the one or more data packets each have a finite time duration;   changing a data rate of the transmissions of the one or more data packets;   and automatically adjusting the fragmentation threshold in response to the data rate change so that the finite time duration for the one or more data packets remains substantially the same.

This method can also be performed by an access point, a wireless unit, or other device in a wireless network system.   And, the method can also be embodied in a software routine stored on a machine readable medium.

Yet another aspect of the invention relates to a wireless network system comprising a wired backbone network, an access point, and one or more associated wireless unit data coupled to the access point by way of a wireless transmission medium.   In particular, this aspect of the invention is a method of enabling fragmentation of data packet above a fragmentation threshold in one or more wireless units, comprising transmitting a message to the one or more wireless unit having a first control data that

causes the one or more wireless units to implement fragmentation threshold in transmitting data packets to the access point. The message is preferably a multicast data packet intended for the one or more associated

5   wireless units. The message may further include a specified fragmentation to be used, and also another control signal for enabling request to send (RTS) and clear to send (CTS) transmission by the one or more wireless units.

10   Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a block diagram an exemplary wireless network system in accordance with the invention;

20   Figure 2 illustrates a block diagram of an exemplary access point (AP) in accordance with the invention;

Figure 3 illustrates a block diagram of another wireless network system in accordance with the invention;

Figure 4 illustrates a flow chart of an exemplary

25   routine that an AP can perform to automatically adjust the fragmentation threshold;

Figure 5 illustrates a table useful for explaining the relationship between the fragmentation threshold and the data rate; and

30   Figure 6 illustrates a block diagram of an exemplary wireless unit (WU) for performing the various functions in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

Herein, the exemplary embodiments of the present invention relate to a wireless network that includes a

5   fixed wired backbone network, one or more access point (AP) for providing wireless units access to the backbone network via a wireless communications link to the AP. The invention solves this problem by having an AP of a wireless network system automatically determine a factor

10   indicative of the error(s) occurring in the transmissions of one or more data packets to the associated WU, and automatically adjust the fragmentation threshold in accordance with the transmission error factor. The AP adjusts the fragmentation threshold in a manner that the

15   data throughput is increased. Since the AP automatically and periodically gauges the wireless medium for RF interference that can cause data transmission errors, the fragmentation threshold can be dynamically adjusted to respond to changes in the wireless medium, such as when a

20   microwave oven is turned on, and/or when a Blue Tooth device is traversing the wireless medium, etc. This is much more effective than having a system administrator periodically gauge the wireless medium for the purpose of selecting the appropriate fragmentation threshold.

25   In the following description, certain terminology is used to describe features of the present invention. For example, "logic" includes hardware and/or software module(s) that perform a certain function on incoming information. A "software module" is executable code such

30   as an operating system, an application or an applet for example. The term "information" is defined as data, address, and/or control. For transmission, the information may be placed in a frame featuring a single data packet or a series of data packets.

In addition, a "link" is broadly defined as one or more information-carrying mediums to establish a communications pathway. Examples of the medium include a physical medium (e.g., electrical wire, optical fiber,

5 cable, bus traces, etc.) or a wireless medium (e.g., air in combination with wireless signaling technology).

Referring to Figure 1, an exemplary first embodiment of a wireless network system 100 in accordance with the invention is illustrated. The wireless network system 100

10 comprises a link 101 based on a physical medium. Herein, the link 101 is part of a wired backbone network 102 that includes network resources 104 available for users of the system 100. The wireless network system 100 further includes one or more access points (APs) 106a-106d that

15 communicate via a wireless link with one or more wireless units (WUs) 108a-108f. For this embodiment, four (4) APs 106a-106d communicate with six (6) WU 108a-108f.

Users using the WUs 108a-108f can access the network resources 104 via any of the APs 106a-106d, which are

20 generally transparent bridges that link a wireless network defined by one or more WUs 108a-108f with the wired backbone network 102. The WUs 108a-108f communicate with the APs 106a-106d typically using a standardized protocol, such as the IEEE 802.11 protocol.

25 A "wireless unit" (WU) is defined herein as any electronic device comprising processing logic (e.g., a processor, microcontroller, state machine, etc.) and a wireless transceiver for receiving and transmitting data to an access point (AP) or another wireless unit (WU).

30 Examples of a WU include a computer (e.g., desktop computer, laptop computer, hand-held computer such as a personal digital assistant "PDA", etc.), communications equipment (e.g., pagers, telephones, facsimile machine, etc.), a television set-top box, or appliances such as

refrigerator pads, electronic picture frames, alarm
detectors, water detectors, etc. The WU includes hardware
and/or software to receive a notification from an
associated AP of a failed communications link between the
5   associated AP and the wired backbone network 102. In
addition, the WU also includes hardware and/or software to
initiate a search for a new AP to associate with upon
receiving such a notification of a failed communications
link to the wired backbone network 102 from its associated
10   AP.

An "access point" (AP) is a device that provides a
bi-directional connection between one or more WUs and the
wired backbone network 102. However, an AP could also
have a wireless connection back to the backbone network
15   102, such as AP 106d, which has a wireless link to the
backbone network 102 via another AP 106c. The wired
backbone network can be of any type, including an
Ethernet, a token ring, and an asynchronous transfer mode
(ATM) network. The AP of the invention includes hardware
20   and/or software to detect a failed communications link to
the wired backbone network. The AP of the invention also
includes hardware and/or software to notify associated WUs
of the failed communications link so that the WUs take
appropriate action to reestablish their link to the
25   backbone network 102 by way of another AP.

Referring now to Figure 2, an exemplary embodiment of
an access point (AP) is shown. For illustrative purposes,
the access point is represented by AP 106b and differs in
function from the access points described in U.S. Patent
30   No. 5,987,062. As shown, AP 106b comprises logic 200 and
202, an address table 204, a device management module 206,
and a wireless transceiver interface 210. In particular,
the logic 200 is used to determine whether certain
information from the wired backbone network 102 is

destined for one or more of the WUs. The address table
204 includes media access controller (MAC) addresses for
all of the wireless units associated with the AP 106b such
as WUs 108c-d of Figure 1. In the special case of all
5   broadcast or some multicast packets, the packets are
addressed to all or some of the wireless units (WUs)
associated with the access point (AP) on a "best efforts"
basis.

        Similarly, as information from wireless units (WU) is
10   received by the wireless transceiver 210, the logic 202
monitors addresses within this information against the
contents of the address table 204. One reason is that
only information from authenticated and associated
wireless units (e.g., WUs 108c-d) is accepted. Hence, if
15   a non-authenticated wireless unit transmits packets, these
packets will not be forwarded to the wired backbone
network 102 of Figure 1. The logic 202 subsequently
transmits the information to the logic 200 for routing to
the wired backbone network 102.

20   In the event that the fixed backbone network 102 of
Figure 1 has a substantially larger data rate than the
wireless network, content addressable memory (CAM) 212 and
a hardware address filter (HAF) 214 are employed within
the AP 106b. The CAM 212 and HAF 214 are in communication
25   with the fixed backbone network 102 and collectively
filter information at the hardware level so that the logic
200 processes only a small portion of the information
routed over the wired backbone network 102.

        The device management module 206 provides a mechanism
30   for adjusting the various parameters and controlling the
functionality of the AP 106b. An example of one mechanism
involves placement of a serial port 216 within the AP
106b. The serial port 216 provides a direct connection to
the AP 106b. Other mechanisms include (1) Simple Network

Management Protocol (SNMP) management tools such as
OPTIVITY® by Nortel Networks Limited of Montreal, Canada,
(2) TELNET, or (3) web-based management software.

   Referring back to Figure 1, in a typical scenario, a

5 WU associates itself with one of the APs to communicate
with the wired backbone network 102. For instance, in the
example shown in Figure 1, WUs 108a-b are associated with
AP 106a, WUs 108c-d are associated with AP 106b, WU 108e
is associated with AP 106c, and WU 108f is associated with

10 wireless AP 106d. Which access point (AP) a wireless unit
(WU) is associated with can depend on many factors,
including signal quality, load balancing, restricted links
and other factors. The APs associated with a particular
WU can change, such as when the WU "roams" from the

15 coverage area of a particular AP to a coverage area of
another AP. From the standpoint of the user using the WU,
this change in associated AP is transparent.

   Figure 3 illustrates an exemplary second embodiment
of a wireless network system 300 in accordance with the

20 invention. The wireless network system 300 comprises two
or more sub-networks 302a-b, which communicate with each
other by way of a router 304. The sub-networks 302a-b can
be any wired backbone network, including Ethernet, token
ring, and an asynchronous transfer mode (ATM) network.

25 The sub-networks 302a-302b need not be of the same type,
for instance, sub-network 302a can be an Ethernet, and
sub-network 302b can be a token ring. Each sub-network
302a-b has one or more APs for communicating with
associated WUs. For instance, sub-network 302a includes

30 APs 306a-1, 306a-2, 306a-3 for communicating respectively
with WUs 308a-1, 308a-2, and 308a-3. Sub-network 302b
includes APs 306b-1 and 306b-2 for communicating
respectively with WUs 308b-1 and 308b-2. In this system,
a WU associated with an AP on a particular sub-network

(e.g. sub-network 302a) can also change its association to an AP on another sub-network (e.g. sub-network 302b) by roaming as discussed above or other circumstances.

As previously discussed, a problem with the current
5   wireless network deals is that RF interference in a wireless environment is typically very dynamic, and therefore, a system administrator cannot practically determine and adjust the fragmentation threshold for every change in the wireless environment. For example, a person
10   in an office or a home can turn on the microwave oven for 30 seconds. During that period, the RF interference in the wireless medium increases. However, it would be impractical or even impossible for a system administrator to gauge the wireless environment for the purposes of
15   determining the optimal fragmentation threshold each time a person turns on a microwave oven or some other RF interference source.

The invention solves this problem by having an AP of a wireless network system automatically determine a factor
20   indicative of the error(s) occurring in the transmissions of one or more data packets to the associated WU, and automatically adjust the fragmentation threshold in accordance with the transmission error factor. The AP adjusts the fragmentation threshold in a manner that the
25   data throughput is increased. Since the AP automatically and periodically gauges the wireless medium for RF interference that can cause data transmission errors, the fragmentation threshold can be dynamically adjusted to respond to changes in the wireless medium, such as when a
30   microwave oven is turned on, and/or when a Blue Tooth device is traversing the wireless medium, etc. This is much more effective than having a system administrator periodically gauge the wireless medium for the purpose of selecting the appropriate fragmentation threshold.

Figure 4 illustrates a flow chart of an exemplary
routine 400 that an AP can perform in automatically
adjusting the fragmentation threshold to increase data
throughput in the presence of significant RF interference.
In step 402, the AP first transmits one or more data
packets to one or more associated WU(s) in the normal
course of sending data to the WU(s).   In step 404, the AP
determines a factor indicative of the error(s) that
occurred in the transmission of the one or more data
packets to the WU(s).   Since the 802.11 wireless network
system uses a positive acknowledgment protocol (i.e. the
transmission of an acknowledge packet when a data packet
is successfully received) for data that is transmitted via
the wireless medium, the AP can determine the transmission
error factor by the amount of acknowledgment packet(s)
received in response to its transmissions of the one or
more data packet(s).

In step 406, the AP compares the transmission error
factor to a pre-determined upper threshold.   The pre-
determined upper threshold is a maximum transmission error
factor that could be tolerated without having to decrease
the fragmentation threshold.   If the transmission error
factor increases above the upper threshold as determined
in step 406, this indicates that significant data
transmission errors are occurring in the wireless medium
requiring a decrease in the fragmentation threshold.
Accordingly, in step 408 the fragmentation threshold is
reduced, and the AP subsequently transmits one or more
data packet(s) to the associated WU(s) using the new
fragmentation threshold.   If the transmission error factor
is below the upper threshold as determined in step 406,
this indicates that significant data transmission errors
are not occurring in the wireless medium, and the routine
proceeds to step 410.

In step 410, the AP compares the transmission error
factor to a pre-determined lower threshold. The pre-
determined lower threshold is a minimum transmission error
factor for which an increase in the fragmentation
5 threshold is not necessitated. If the transmission error
factor falls below the lower threshold as determined in
step 410, this indicates that fragmentation threshold can
be increased in order to increase the data throughput
through the wireless medium. Accordingly, in step 412 the
10 fragmentation threshold is increased, and the AP
subsequently transmits one or more data packet(s) to the
associated WU(s) using the new fragmentation threshold.
If the transmission error factor is above the lower
threshold as determined in step 410, this indicates that
15 there are some data transmission errors, not significant
as to require a decrease in the fragmentation threshold,
but significant enough not to increase it either. Thus,
the current fragmentation threshold is maintained, and the
AP subsequently transmits one or more data packet(s) to
20 the associated WU(s) using the current fragmentation
threshold.

With regard to step 404, there are many algorithms
that an AP can use to determine the transmission error
factor for the purpose of adjusting the fragmentation
25 threshold. For instance, the transmission error factor
can be a percentage of data transmission errors that
occurred within a given time period. This method,
however, may not be desirable because data transmission
errors can be common in a system. A more effective method
30 of determining a transmission error factor is to weigh
transmission errors that occur successively (i.e. clusters
of transmission errors) greater than those errors that
occur sporadically. If transmission errors occur
successively, this indicates that there may be a problem,

such as a temporary increase in RF interference, in the
wireless medium.   Other methods of determining a
transmission error factor can be based on an empirical
modeling of the wireless channel.   There are many other

5   methods of determining a transmission error factor for the
purpose of adjusting the fragmentation threshold.

       With regard to steps 408 and 412 of reducing and
increasing the fragmentation threshold, this can be
accomplished in many ways.   For instance, once it has been

10   determined that the fragmentation threshold has to be
reduced or increased in step 406 or 410, the AP can
decrement or increment the fragmentation threshold by one
or some other fixed quantity.   Using this method, and
repeating the routine 400 depicted in Figure 4, a

15   fragmentation threshold that provides optimal data
throughput for the system can be achieved.

       Another method of adjusting the fragmentation
threshold is to use a divisional factor where the current
fragmentation threshold is given by a maximum

20   fragmentation threshold divided by the divisional factor.
The maximum fragmentation threshold is preferably set at
or above the maximum packet size specified by the wired
backbone network protocol.   If an Ethernet type network is
used, the maximum data packet size is 1518 bytes.   Thus,

25   the maximum fragmentation threshold is set to 1518 bytes.
If there is minimal RF interference in the wireless
medium, the divisional factor is set to 1, thereby making
the fragmentation threshold 1518 and consequently no
fragmentation of data packets occur.   When RF interference

30   initially occurs that causes the transmission error factor
to increase above the upper threshold (See Figure 4), the
divisional factor is increased to 2, thereby reducing the
fragmentation threshold to 759.   If the transmission error
factor is still above the upper threshold, the divisional

factor is increased again to 3, thereby reducing the fragmentation threshold to 506, and so on. Similarly, the divisional factor is decreased when the transmission error factor falls below the lower threshold (See Figure 4).

5   The advantage of using fixed steps to adjust the fragmentation threshold is that generally a fragmentation threshold is arrived that produces a more optimum data throughput. However, because the changes in the fragmentation threshold are by fixed steps, it takes a

10 relatively long time to arrive at the optimum fragmentation threshold. The advantage of using the divisional factor to adjust the fragmentation threshold is that the change in the threshold is quick at the beginning to attack the problem faster, but changes slowly as the

15 problem increases. This adjustment of the fragmentation threshold parallels how environment changes occur in networks. The only drawback with this method is that the optimal fragmentation threshold may lie at a value not capable of being reached because of the discrete steps of

20 the divisional factor. In any event, the above two methods of adjusting the fragmentation threshold are merely examples. There are many other ways to adjust the fragmentation threshold in response to changes in the wireless medium environment.

25 Another consideration is the time length of a data packet when data rates are changed and fragmentation of data is being performed to increase data throughput in the presence of significant RF interference. The time duration of a data packet is given by the size of the

30 packet divided by the data rate. Fragmenting a data packet (i.e. reducing the size of a data packet), therefore, makes its duration shorter. If a data packet has a relatively long duration, it is more prone to be adversely affected by RF interference. This is the reason

why the data size of data packets are made smaller by
fragmentation to reduce duration of the packets so that
they are less vulnerable to RF interference. However, as
previously stated, the duration of a data packet is not
5   only a function of data size, but also of the data rate.
So changes in the date rate should be taken into account
when fragmentation is employed in order to maintain the
desired duration for the packet.

Figure 5 illustrates a table useful for explaining
10   the relationship between the fragmentation threshold and
the date rate. The left-most column lists divisional
factor for four exemplary scenarios, with the maximum
fragmentation threshold being 1500 for all the scenarios.
The second column lists the date rates for the four
15   exemplary scenarios. And, the right-most column is a time
line of the data packet payloads and corresponding
acknowledgement packets for the four exemplary scenarios.

In the first scenario, the divisional factor is 1,
thereby making the fragmentation threshold 1500 bytes
20   (i.e. the maximum fragmentation threshold of 1500 divided
by the divisional factor of 1). The data rate for the
first scenario is 11 Megabytes per second (Mbytes/s).
Assuming the size of the payload of the data packet is the
same as the fragmentation threshold, then the duration of
25   the payload is 136 microseconds.

In the second scenario, significant RF interference
is present in the wireless medium which causes the AP to
reduce the fragmentation threshold by increasing the
divisional factor from one to two. Thus, the
30   fragmentation threshold is 750 bytes (i.e. the maximum
fragmentation threshold of 1500 divided by the divisional
factor of 2). The date rate for this scenario is
maintained at 11 Mbytes/s. Assuming the size of the
payload of the data packet is the same as the

fragmentation threshold, then the duration of the payload
has been shortened to 68 microseconds. This illustrates
that the original data payload having a duration of 136
microseconds was too long that it was prone to adverse

5   effects from the RF interference. By shortening the
duration of the payload to 68 microseconds with
fragmentation, the data packet is less prone to the RF
interference.

     In the third scenario, the data rate has been reduced
10   to 5.5 Mbytes/s. This may be done by a system
administrator for any number of reasons. In this
scenario, the divisional factor of 2 is maintained the
same, thereby the fragmentation threshold is again 750
bytes. Assuming the size of the payload of the data
15   packet is the same as the fragmentation threshold, then
the duration of the payload returns back to 136
microseconds due to the data rate change. However, it has
already been determined that a duration of 136
microseconds for the payload makes the data packet prone
20   to adverse effects from the RF interference. To correct
this, the fragmentation threshold has to be reduced by
half again to maintain the duration of the payload at 68
microseconds, where the data packet is less prone to
adverse effects from RF interference.

25   Thus, in the fourth scenario, the divisional factor
has been increased to 4, thereby making the fragmentation
threshold 375 bytes (i.e. the maximum fragmentation
threshold of 1500 divided by the divisional factor of 4).
Again, the fragmentation threshold has been decreased to
30   compensate for the decrease in the data rate from 11 to 5
Mbytes/s. Thus, the duration of the data payload is 68
microseconds, where the data packet is less prone to
adverse effects from RF interference. This example
illustrates the concept that if fragmentation is being

used and there is a data rate change, the fragmentation threshold has to similarly change in order to maintain substantially the same duration for the data packet.

As previously discussed, in order for fragmentation
5   and/or RTS/CTS transmission to optimally work in a wireless network system, the AP as well as its associated WU(s) should all use fragmentation and/or RTS/CTS transmission.   However,   in   current   wireless   network systems, a system administrator has to manually enable
10   each AP and associated WU(s) when fragmentation is desired.   Likewise, a system administrator has to enable each AP and associated WU(s) when RTS/CTS transmission is desired.   Since there can be many APs and WUs in a wireless network system, having a system administrator go
15   around to all of these units to enable fragmentation and/or RTS/CTS is cumbersome, costly and time-consuming.

The invention solves this problem by having an AP transmit a multicast packet including a control signal that enables fragmentation and/or RTS/CTS transmissions in
20   the associated WU(s).   The multicast packet also includes the fragmentation threshold to be used.   Thus, instead of a system administrator having to manually enable the AP and each of the associated WU(s) for fragmentation and/or RTS/CTS transmissions, with the use of the multicast
25   packet, the AP automatically enables these functions for all the associated WU(s).   This is a substantial saving in time and money, and is substantially less cumbersome.

In the preferred embodiment, the multicast data packet sent out by the APs conform to an Inter Access
30   Point Protocol (IAPP) developed by Netwave Technologies, Inc., now owned by Nortel Networks Limited.   The IAPP protocol is used for automated hop sequence between APs, handover notification when a WU roams from one AP to another AP, and for delivery of various AP information,

such as the AP network protocol address and subnet mask as
previously discussed. The IAPP uses an IEEE 802.3 frame
format with the sub-network access protocol (SNAP).   The
IAPP broadcast packet includes a header defining various
5   parameters such as destination address which is typically
set to a multicast address, a source address set to the
network protocol address of the transmitting AP, length of
the packet, and other information, and a payload which
includes informational elements such as the AP name, the
10   number of associated WU(s) (i.e. the head count), a
control   signal   for   enabling   fragmentation   in   the
associated WU(s), the fragmentation threshold to be used,
a control signal for enabling RTS/CTS transmissions in the
associated WU(s), and other information.

15   Referring   back   to   Figure   2,   the   AP   106b   of   the
invention   includes   a   logic   circuit,   such   as   the   device
management module 206, for generating and transmitting to
the associated WU(s), a multicast packet (e.g. the IAPP
multicast packet described above) that includes a control
20   signal   for   causing   the   associated   WU(s)   to   fragment   data
packets if the payload is above a fragmentation threshold.
The multicast packet also contains an information element
of the desired fragmentation threshold.   Along this line,
the   AP   106b   of   the   invention   includes   a   logic   circuit,
25   such as the device management module 206b, for determining
when   to   employ   fragmentation   and   at   what   fragmentation
threshold   based   on   a   factor   indicative   of   the   data
transmission error to the associated WU(s) and/or data
rate changes.   Such a logic circuit can also determine the
30   data   transmission   error   factor   based   on   many   different
algorithms such as the ones discussed above or others.

The   AP106   of   the   invention   also   includes   a   logic
circuit,   such   as   the   device   management   module   206,   for
generating   and   transmitting   to   the   associated   WU(s),   a

multicast packet (e.g. the IAPP multicast packet described above) that includes a control signal for causing the associated WU(s) to perform RTS/CTS transmissions. In addition, the logic circuit of AP 106b can also
5   automatically determine when to employ RTS/CTS transmissions for itself and the associated WU(s) based upon such factors as the number of associated WUs (i.e. the head count), and/or the number of retry transmission counts, and/or the number of collisions.

10   Figure 6 illustrates a block diagram of an exemplary wireless unit (WU) 600 for performing the various functions in accordance with the invention. As previously discussed, examples of a WU 600 include a computer (e.g., desktop computer, laptop computer, hand-held computer such
15   as a personal digital assistant "PDA", etc.), communications equipment (e.g., pagers, telephones, facsimile machine, etc.), a television set-top box, or appliances such as refrigerator pads, electronic picture frames, alarm detectors, water detectors, etc. The WU 600
20   comprises a wireless transceiver 602 for transmitting and receiving RF data packets to and from an AP, a logic circuit 604 for performing the various functions of the WU 600, a memory 606 for storing data and applications relating to the various functions of the WU 600, and a
25   user interface 608 for receiving and presenting information from and to a user of the WU 600. Such user interface 608 can include a keyboard, pointing device (e.g. a mouse, a track ball, etc.), a microphone, display, speakers and other devices for conveying and receiving
30   information to and from a user.

    With regard to the invention, the logic circuit 604 of the WU 600 receives by way of the wireless transceiver 602 the multicast packet (e.g. the IAPP multicast packet described above) transmitted by the associated AP that

includes the control signal for causing the WU 600 to
fragment data packets if the payload is greater than a
fragmentation threshold.   The specified fragmentation
threshold is also included in the multicast packet.   The

5   logic circuit 604 stores the specified fragmentation
threshold in memory 606 and sets a flag for performing
fragmentation.   The logic circuit 604 will thereafter
fragment each data packet whose payload is greater than
the fragmentation threshold, and transmits the two or more

10   fragments as individual packets to the associated AP by
way of the wireless transceiver 602.   If the payload of
the data packet is less than the fragmentation threshold,
the logic circuit 604 simply transmits the whole packet to
the associated AP by way of the wireless transceiver 602.

15   Alternatively, the WU 600 can also determine on its
own, without instructions from the associated AP, whether
to perform fragmentation of data packets based on data
transmission errors, data rate changes, and/or other
factors.   Specifically, the logic circuit 604 can make

20   such a determination using the same one or more routines
performed by an AP, as described with reference to Figures
4 and 5.   If the logic circuit 604 determines that
fragmentation   is   needed,   it   can   determine   the
fragmentation threshold using the same one or more

25   routines performed by an AP, as described with reference
to Figures 4 and 5.

     Also with regard to the invention, the logic circuit
604 of the WU 600 receives by way of the wireless
transceiver 602 the multicast packet (e.g. the IAPP

30   multicast packet described above) transmitted by the
associated AP that includes the control signal for causing
the WU 600 to perform RTS/CTS transmissions.   In response
to this control signal, the logic circuit 604 sets a flag
that enables RTS/CTS transmissions.   The logic circuit 604

will thereafter transmit an RTS packet prior to sending a data packet to the associated AP by way of the wireless transceiver 602, and wait a pre-determined time interval to receive a CTS packet from the associated AP. If the
5   logic circuit 604 receives the CTS packet from the associated AP within the pre-determined time interval, then the logic circuit 604 transmits the corresponding data packet during the reserved time slot following the receipt of the CTS packet. If the logic circuit 604 does
10 not receive the CTS packet within the pre-determined time interval, the logic circuit 604 retransmits another RTS packet and repeats the same process again.

        Alternatively, the WU 600 can also determine on its own, without instructions from the associated AP, whether
15 to perform RTS/CTS transmissions based on the amount of associated WUs, number of retry transmissions, number of collisions, and/or how proximate other associated WUs are by monitoring their signal strength on data. Specifically, the logic circuit 604 can make such a
20 determination using the same one or more routines performed by an AP, as described with reference to Figures 4 and 5.

        In the foregoing specification, the invention has been described with reference to specific embodiments
25 thereof. It will, however, be evident that various modifications and changes may be made thereto departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive
30 sense.